

PRACTICE PROBLEMS

Note: Unless instructed otherwise in a problem, use the following properties:

steel:	$E = 30 \times 10^6 \text{ lbf/in}^2$ ($20 \times 10^4 \text{ MPa}$)
	$G = 11.5 \times 10^6 \text{ lbf/in}^2$ ($8.0 \times 10^4 \text{ MPa}$)
	$\alpha = 6.5 \times 10^{-6} \text{ 1/}^\circ\text{F}$ ($1.2 \times 10^{-5} \text{ 1/}^\circ\text{C}$)
	$\nu = 0.3$
aluminum:	$E = 10 \times 10^6 \text{ lbf/in}^2$ ($70 \times 10^3 \text{ MPa}$)
copper:	$E = 17.5 \times 10^6 \text{ lbf/in}^2$ ($12 \times 10^4 \text{ MPa}$)

1. The yield strength of a structural steel member is 36,000 lbf/in² (250 MPa). The tensile stress is 8240 lbf/in² (57 MPa). What is the factor of safety in tension?

- (A) 2.5
- (B) 3.1
- (C) 3.6
- (D) 4.4

2. A structural steel member 50 ft (15 m) long is used as a long column to support 75,000 lbf (330 kN). Both ends are built-in, and there are no intermediate supports. A factor of safety of 2.5 is used. What is the required moment of inertia?

- (A) 48 in⁴ ($2.0 \times 10^{-5} \text{ m}^4$)
- (B) 72 in⁴ ($3.0 \times 10^{-5} \text{ m}^4$)
- (C) 96 in⁴ ($4.0 \times 10^{-5} \text{ m}^4$)
- (D) 130 in⁴ ($5.5 \times 10^{-5} \text{ m}^4$)

3. A long steel column with a yield strength of 36,000 lbf/in² (250 MPa) has pinned ends. The column is 25 ft (7.5 m) long, has a cross-sectional area of 25.6 in² (165 cm²), a centroidal moment of inertia of 350 in⁴ (14,600 cm⁴), and a distance from the neutral axis to the extreme fiber of 7 in (180 mm). It carries an axial concentric load of 100,000 lbf (440 kN) and an eccentric load of 150,000 lbf (660 kN) located 3.33 in (80 mm) from the longitudinal axial axis. Use the secant formula to determine the stress factor of safety.

- (A) 1.2
- (B) 1.5
- (C) 1.7
- (D) 1.9

4. A rectangular tank with dimensions of 2 ft by 2 ft by 1 ft (60 cm by 60 cm by 30 cm) is pressurized to 2 lbf/in² gage (14 kPa). The steel plate used to construct a tank has a thickness of 0.25 in (6.3 mm) and a yield stress of 36 ksi (250 MPa). Neglecting stress concentration factors at the corners and edges, what is the factor of safety?

- (A) 3.1
- (B) 3.7
- (C) 4.2
- (D) 6.3

5. A short section of pipe with an inside diameter of 1.750 in (44.5 mm) is to be produced by turning and boring bar stock. The steel has an allowable normal stress of 20,000 lbf/in² (140 MPa). The pipe will be pressurized internally to 2000 lbf/in² gage (14 MPa). Disregard longitudinal stress and other end effects. Use a thick-walled analysis to determine the required outside diameter.

- (A) 1.9 in (49 mm)
- (B) 2.2 in (56 mm)
- (C) 2.6 in (66 mm)
- (D) 3.9 in (99 mm)

6. A pressurized cylinder has an inside diameter of 0.742 in (18.8 mm) and an outside diameter of 1.486 in (37.7 mm). The cylinder is subjected to an external pressure of 400 lbf/in² gage (2.8 MPa). What is the maximum stress developed in the cylinder?

- (A) -1100 lbf/in² (-7.5 MPa)
- (B) -1600 lbf/in² (-12 MPa)
- (C) -2500 lbf/in² (-18 MPa)
- (D) -3600 lbf/in² (-28 MPa)

7. A shell with an outside diameter of 16 in (406 mm) and a wall thickness of 0.10 in (2.54 mm) is subjected to a 40,000 lbf/in² (280 MPa) tensile load and a 400,000 in-lbf torque (45 kN-m).

- (a) What are the principal stresses?
- (b) What is the maximum shear stress?

8. (Time limit: one hour) A projectile launcher is formed by shrinking a jacket over a tube of the same length. The assembly is made with the maximum allowable diametral interference. The tube inside and outside diameters are 4.7 in and 7.75 in (119 mm and 197

52 Advanced Machine Design

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1. A spring with 12 active coils and a spring index of 9 supports a static load of 50 lbf (220 N) with a deflection of 0.5 in (12 mm). The shear modulus of the spring material is 1.2×10^7 lbf/in² (83 GPa).

(a) What is the theoretical wire diameter?

- (A) 0.58 in (15 mm)
- (B) 0.63 in (16 mm)
- (C) 0.69 in (18 mm)
- (D) 0.74 in (19 mm)

(b) What is the mean spring diameter?

- (A) 5.2 in (140 mm)
- (B) 6.4 in (160 mm)
- (C) 7.1 in (180 mm)
- (D) 7.9 in (200 mm)

2. A severe service valve spring is to be manufactured from unpeened ASTM A230 steel wire in standard W & M sizes operating continuously between 20 lbf and 30 lbf (100 N and 150 N). The valve lift is 0.3 in (8 mm). The spring index is 10. The factor of safety is 1.5.

(a) What is the wire diameter?

- (A) 0.12 in (3.0 mm)
- (B) 0.15 in (4.1 mm)
- (C) 0.21 in (5.3 mm)
- (D) 0.28 in (7.1 mm)

(b) What is the spring constant?

- (A) 10 lbf/in (1.9 kN/m)
- (B) 21 lbf/in (3.9 kN/m)
- (C) 33 lbf/in (6.3 kN/m)
- (D) 48 lbf/in (92 kN/m)

(c) What is the number of active coils if the ends are squared and ground?

- (A) 4.7
- (B) 5.2
- (C) 6.4
- (D) 8.6

(d) What is the total number of coils?

- (A) 6.2
- (B) 6.9
- (C) 7.8
- (D) 8.4

(e) What is the solid height?

- (A) 1.2 in (35 mm)
- (B) 1.7 in (43 mm)
- (C) 2.3 in (58 mm)
- (D) 2.8 in (71 mm)

(f) What is the spring force at solid height?

- (A) 32 lbf (10 N)
- (B) 46 lbf (250 N)
- (C) 53 lbf (290 N)
- (D) 62 lbf (330 N)

(g) What is the deflection at solid height?

- (A) 1.4 in (39 mm)
- (B) 1.7 in (43 mm)
- (C) 2.1 in (53 mm)
- (D) 2.4 in (61 mm)

(h) What is the minimum free height?

- (A) 2.1 in (53 mm)
- (B) 2.6 in (75 mm)
- (C) 3.2 in (81 mm)
- (D) 4.5 in (110 mm)

3. The material in a spring wire has a shear modulus of 1.2×10^7 lbf/in² (83 GPa). The maximum allowable stress under design conditions is 50,000 lbf/in² (350 MPa). The spring index is 7. Assume the maximum stress is experienced when a 700 lbf (320 kg) object falls from a height of 46 in (120 cm) above the tip of the spring, impacts squarely on the spring, and deflects the spring 10 in (26 cm).

(a) What is the minimum wire diameter?

- (A) 0.6 in (15 mm)
- (B) 0.9 in (23 mm)
- (C) 1.4 in (36 mm)
- (D) 1.8 in (47 mm)

(b) What is the mean coil diameter?

- (A) 8.6 in (220 mm)
- (B) 10 in (250 mm)
- (C) 13 in (330 mm)
- (D) 16 in (410 mm)

(c) What is the number of active coils?

- (A) 8
- (B) 10
- (C) 12
- (D) 14

4. A 6 in (150 mm) wide, 24 in (610 mm) long cantilever steel spring supports an 800 lbf (3.5 kN) load at its tip. The deflection is to be less than 1 in (25 mm). The bending stress is limited to 50,000 lbf/in² (345 MPa).

(a) What is the minimum thickness as limited by deflection alone?

- (A) 0.37 in (9.4 mm)
- (B) 0.45 in (11 mm)
- (C) 0.63 in (16 mm)
- (D) 0.77 in (20 mm)

(b) What is the minimum thickness as limited by bending stress?

- (A) 0.62 in (15.7 mm)
- (B) 0.66 in (16.7 mm)
- (C) 0.72 in (18.3 mm)
- (D) 0.78 in (19.8 mm)

5. A gear train is to have a speed reduction of 600:1. The gears used can have no fewer than 12 teeth and no more than 96 teeth.

(a) How many stages are needed?

(b) How many teeth should be in each gear in the gear train?

6. A mechanism is driven by a 550 hp (410 kW) motor. The motor turns at 1200 rpm, but a pair of old 14½° gears on 15 in (380 mm) centers is to reduce the speed of the mechanism to 270 rpm. The pinion is to be SAE 1045 steel with an endurance strength of 90,000 lbf/in² (620 MPa). The gear is to be cast steel with an endurance strength of 50,000 lbf/in² (345 MPa). A safety factor of 3 is used in the design. Use the Lewis beam strength theory. Do not check for undercutting.

(a) What are the pitch diameters?

(b) Given a pinion face width of 6 in (150 mm), what is the diametral pitch?

(c) Given a diametral pitch of 1.5 (a module of 17 mm), what should be the face width for the gear?

7. Two 20° involute spur gears are mounted such that their centers are 15 in (380 mm) apart. The pinion is untreated steel with an allowable stress of 30,000 lbf/in² (210 MPa). The gear set reduces the speed of a 250 hp motor (190 kW) with an integral speed reducer from 250 rpm to 83⅓ rpm. The gear is cast steel with a maximum strength of 50,000 lbf/in² (345 MPa). A factor of safety of 3 is used. Use the Lewis beam strength theory.

(a) What are the pitch diameters?

(b) What is the diametral pitch?

(c) Given a diametral pitch of 1.75, how many teeth are on each gear?

(d) Given a diametral pitch of 1.75, what is the minimum face width of the pinion?

(e) Given a diametral pitch of 1.75, what is the minimum face width of the gear?

12. A piece of equipment is driven by a 15 hp (11.2 kW) motor through a standard B90 V-belt. The motor runs at 1750 rpm. The nominal speed of the equipment must be 800 rpm. The motor's sheave diameter is 10 in (254 mm).

(a) What is the pitch length of the belt?

- (A) 77 in (2000 mm)
- (B) 81 in (2100 mm)
- (C) 86 in (2200 mm)
- (D) 92 in (2300 mm)

(b) What is the pitch diameter of the sheave on the equipment drive?

- (A) 20 in (520 mm)
- (B) 22 in (560 mm)
- (C) 24 in (610 mm)
- (D) 26 in (660 mm)

for the steel is 11.5×10^6 lbf/in² (79 GPa). The springs support a static force of 150 lbf (660 N). The spring dimensions and properties are as follows.

inner spring

wire diameter:	0.177 in	(4.5 mm)
mean coil diameter:	1.5 in	(38 mm)
free length:	4.5 in	(115 mm)
total number of coils:	12.75	

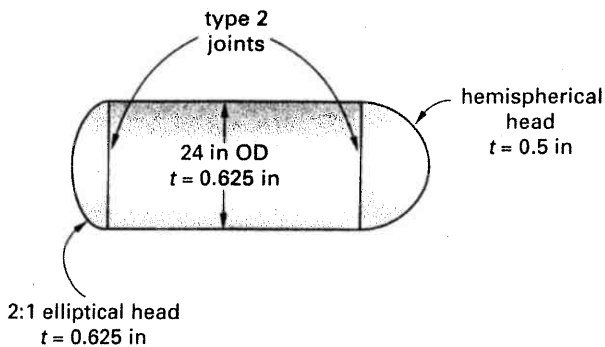
outer spring

wire diameter:	0.2253 in	(5.723 mm)
mean coil diameter:	2.0 in	(51 mm)
free length:	3.75 in	(95.3 mm)
total number of coils:	10.25	

53 Pressure Vessels

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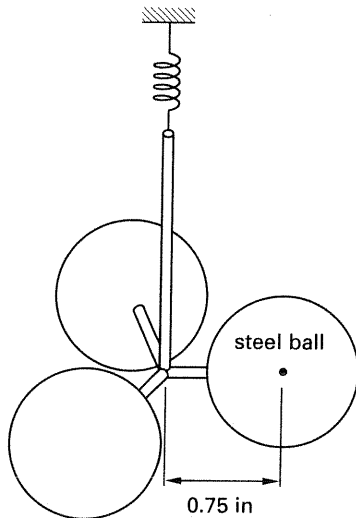
4. A pressure vessel previously used in a refinery has been out of service for a number of years. The vessel is known to be constructed from 0.625 in SA-516, grade 65 plate, but no other documentation is available. The longitudinal seam joint in the vessel is type 1, and the heads are attached with type 2 joints. The vessel is spot radiographed and operates at 850°F. The corrosion allowance is $\frac{1}{16}$ in.



- (a) What is the maximum design pressure?
- (A) 300 psig
 - (B) 350 psig
 - (C) 430 psig
 - (D) 530 psig
- (b) What is the hydrostatic test pressure most nearly if the vessel is tested at room temperature?
- (A) 600 psig
 - (B) 800 psig
 - (C) 900 psig
 - (D) 1000 psig

Afternoon Session Machine Design

81. A rotary pendulum comprises a vertical axis, three steel balls spinning around that axis, and an ideal torsional spring resisting the motion. Arms supporting the balls are rigid and massless, the distance from the vertical axis to ball centers is 0.75 in, and the torsional spring constant is 2.857×10^{-3} in-lbf/rad. The steel ball diameter and density are 1.00 in and 0.284 lbm/in³, respectively. What is most nearly the natural torsional frequency of the pendulum?

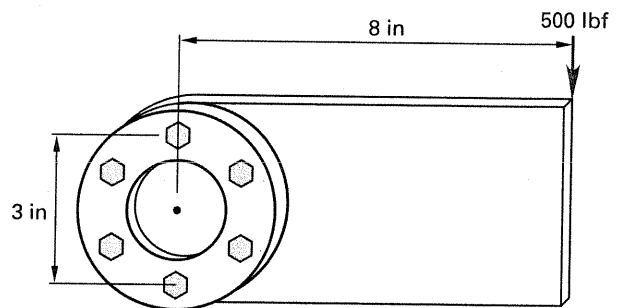


- (A) 0.19 Hz
- (B) 0.31 Hz
- (C) 0.35 Hz
- (D) 0.53 Hz

82. A 500 lbm artillery projectile is launched with initial velocity of 2000 ft/sec, launch angle of 25° from the horizontal, and impact elevation of 2500 ft below the launch elevation. Neglecting air resistance, what is most nearly the horizontal travel distance?

- (A) 10 mi
- (B) 18 mi
- (C) 19 mi
- (D) 43 mi

83. A 500 lbf load is eccentrically applied to a 3 in diameter circle of six bolts as shown. What is most nearly the maximum bolt shear load?



- (A) 370 lbf
- (B) 450 lbf
- (C) 490 lbf
- (D) 510 lbf

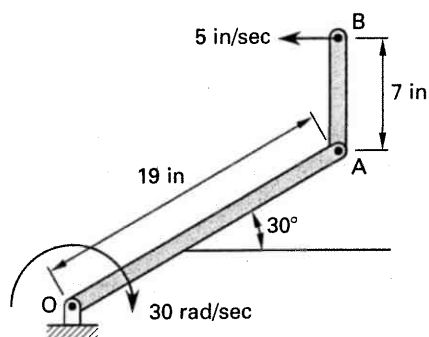
84. A titanium tube is loaded in torsion. The 2 ft long tube has a 2 in outside diameter and a 0.125 in wall thickness. The tensile modulus of elasticity is 15.9×10^6 lbf/in². The maximum applied torque is 50,000 in-lbf. The maximum angular deflection is most nearly

- (A) 0.026 rad
- (B) 0.12 rad
- (C) 0.31 rad
- (D) 0.56 rad

85. A radial ball bearing has a basic load rating of 5660 lbf based on life of 1,000,000 cycles. The bearing supports a 5000 lbf radial load and a 4000 lbf thrust load. The radial loading factor is 0.56, the thrust loading factor is 1.31, the outer ring rotates, and there is no shock loading. What is most nearly the expected service life?

- (A) 280×10^3 cycles
- (B) 350×10^3 cycles
- (C) 710×10^3 cycles
- (D) 840×10^3 cycles

86. A two-bar linkage is rotating about a fixed point O with a constant angular velocity of 30 rad/sec as shown. At a particular moment, bar OA forms an angle of 30° with the horizon, and the velocity of point B is 5 in/sec directed horizontally to the left.



The instantaneous angular velocity of bar AB is most nearly

- (A) 33 rad/sec
- (B) 40 rad/sec
- (C) 67 rad/sec
- (D) 80 rad/sec

87. A spur gear has a pitch diameter of 4.00 in, face width of 1.67 in, 34 teeth, and a Lewis form factor of 0.138. Bending stress at the tooth root is limited to 40,000 lbf/in². Disregarding stress concentration, what is most nearly the allowable tangential load per tooth?

- (A) 3400 lbf
- (B) 10,700 lbf
- (C) 24,900 lbf
- (D) 33,600 lbf

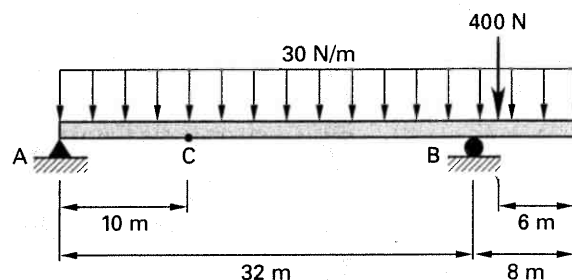
88. A simply supported rectangular-section steel beam is 3.0 in wide, 0.32 in thick, and 35.0 in long. Bending stress is limited to 29,000 lbf/in². Deflection is limited to 0.50 in. Neglect buckling. The maximum point load that can be supported at the beam midpoint is most nearly

- (A) 65 lbf
- (B) 85 lbf
- (C) 140 lbf
- (D) 170 lbf

89. A helical compression spring made of 0.225 in diameter steel wire has a 2.20 in OD and a 6 in free length. Allowable shear stress is 95,000 lbf/in². The spring is dynamically compressed to 150 lbf. What is most nearly the factor of safety?

- (A) 0.81
- (B) 1.10
- (C) 1.20
- (D) 1.40

90. A cantilevered beam 40 m long is supported at its left end and 8 m from its right end, as shown. The beam bears a uniform load of 30 N/m and a concentrated load of 400 N applied 6 m from its right end. What is most nearly the vertical shear acting on the beam at point C?



- (A) 130 N
- (B) 430 N
- (C) 750 N
- (D) 1200 N

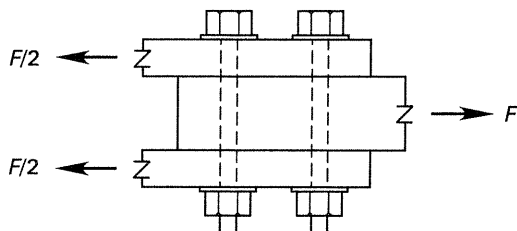
91. A cylindrical tank is produced from layers of a low- ϵ glass, fiber-reinforced epoxy. The tank contains nitrogen gas at a pressure of 10 MPa. The tank has a mean diameter of 300 mm. The fiber orientation angles in various layers of the tank wall are at 55° with respect to the principal axes along the longitudinal and circumferential directions. There is no torsion on the tank. To limit the compressive stress to 115 MPa in the direction of fiber orientation, what is most nearly the minimum wall thickness?

- (A) 8.7 mm
- (B) 14 mm
- (C) 21 mm
- (D) 33 mm

92. A 3.0 in diameter hollow steel shaft is subjected to a static 10,000 in-lbf bending moment and a static 15,000 in-lbf torsional moment. The material yield stress is 80,000 lbf/in², and the ultimate stress is 120,000 lbf/in². The design factor of safety is 2. The minimum internal diameter is most nearly

- (A) 1.9 in
- (B) 2.1 in
- (C) 2.7 in
- (D) 2.9 in

93. The bolted joint shown is designed to carry a shear force of 14,000 lbf and to fail by bolt shear before the force exceeds 20,000 lbf. Characteristics of candidate bolts are listed in the table. There are no threads in the shear plane. Which size bolt best meets the design specifications?



size (in)	major diameter (in)	minor diameter (in)	yield strength (lbf/in ²)	tensile strength (lbf/in ²)
1/4	0.2500	0.1887	57,500	74,500
3/8	0.3750	0.2983	57,500	74,500
1/2	0.5000	0.4056	57,500	74,500
5/8	0.6250	0.5135	57,500	74,500

- (A) 1/4 in
- (B) 3/8 in
- (C) 1/2 in
- (D) 5/8 in

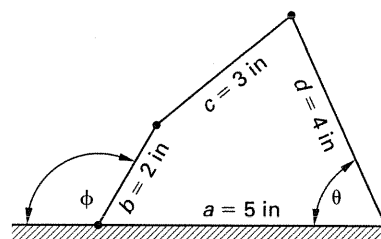
94. A nut tightened on a 1"-8UNC-2A bolt develops the full 105,000 lbf/in² proof stress. The average radius of nut friction forces is 0.625 in, and all friction coefficients are 0.15. Bolt characteristics are as listed.

pitch diameter	0.9188 in
minor diameter	0.8512 in
lead angle	2.48°
thread half angle	30°
minor diameter area	0.551 in ²
tensile stress area	0.606 in ²

What amount of torque is required to tighten the nut to full proof stress?

- (A) 1000 ft-lbf
- (B) 1300 ft-lbf
- (C) 1500 ft-lbf
- (D) 2400 ft-lbf

95. The four-bar linkage in the illustration represents a mechanism. When the input angle ϕ is 120°, what is most nearly the output angle θ ?



- (A) 55°
- (B) 65°
- (C) 75°
- (D) 85°

96. Design engineers must select a structural polymer from the following list of materials. One critical dimension, fabricated to 10.000 in at 25°C, must not exceed 10.045 in at the operating temperature of 80°C. Material weight must be less than half that of aluminum, which has a specific gravity of 2.71. Which is the best material for the application?

material	yield strength (lbf/in ²)	specific gravity	coefficient of thermal expansion (in/in-°C)	maximum operating temperature (°F)
I	4500	1.05	90×10^{-6}	200
II	10,000	1.40	70×10^{-6}	220
III	8000	1.10	80×10^{-6}	170
IV	9300	1.20	70×10^{-6}	260

- (A) I
- (B) II
- (C) III
- (D) IV

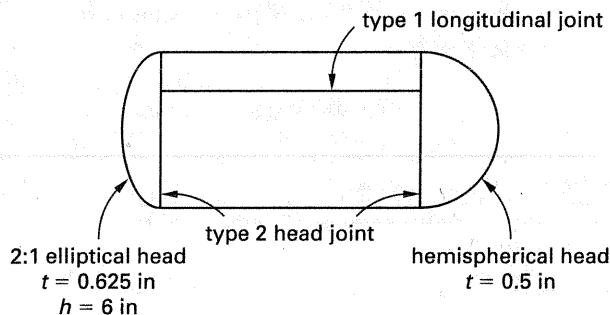
101. A 2 in long plastic push rod has a rectangular section measuring 1.0 in \times 0.7 in. One end is rigidly fixed in place, while the other end is not supported in any direction. The material's tensile modulus is 420,000 lbf/in², and the 2% offset yield strength is 10,000 lbf/in². The critical buckling load is most nearly

- (A) 5100 lbf
- (B) 6100 lbf
- (C) 6700 lbf
- (D) 7400 lbf

102. A manufacturing process follows a standard normal distribution about the mean. Process results within $\pm 3\sigma$ of the mean are accepted; results beyond these limits are reworked or discarded. The probability that the process will produce an accepted result is most nearly

- (A) 68.3%
- (B) 95.4%
- (C) 99.7%
- (D) 99.9%

103. A steel pressure vessel has a 24 in outside diameter, 0.625 in thick shell and elliptical head, 0.5 in thick hemispherical head, and $\frac{1}{16}$ in corrosion allowance. Welds are spot radiographed, and operating temperature is 850°F. Allowable stresses versus temperature and weld joint efficiencies are given in the tables. What is most nearly the maximum design pressure?



temperature (°F)	allowable stress (lbf/in ²)
700	16,700
750	13,900
800	11,400
850	8700
900	5900

structures	weld type	radiography		
		full	spot	none
shells and hemispherical heads	1	1.00	0.85	0.70
shells and hemispherical heads	2	0.90	0.80	0.65
nonhemispherical heads	any	1.00	1.00	0.85

- (A) 350 lbf/in²
- (B) 450 lbf/in²
- (C) 530 lbf/in²
- (D) 690 lbf/in²

104. Design requirements specify that a cell phone's plastic shell must survive a 6 ft fall onto concrete. Static compressions tests indicate shell fracture at 1250 lbf and 0.005 in deflection. If a factor of safety of 6 is used, what is most nearly the maximum allowable phone weight?

- (A) 0.51 lbf
- (B) 0.78 lbf
- (C) 0.95 lbf
- (D) 1.2 lbf

105. A cam follower for a specific application must have zero acceleration at the start of rise. Which cam profile best meets this requirement?

- (A) harmonic
- (B) cycloidal
- (C) parabolic
- (D) velocity derivative

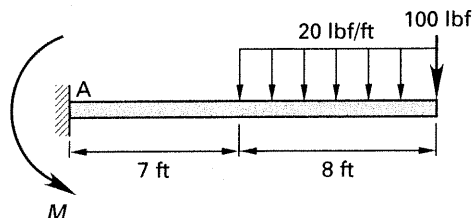
106. A long, thin cantilever beam with a rectangular cross section is subject to lateral vibration. If the thickness of the beam is doubled, the beam's fundamental natural frequency will be

- (A) divided by four
- (B) divided by two
- (C) multiplied by two
- (D) multiplied by four

107. European Union directives require many products sold in Europe to display the CE marking. What is this mark?

- (A) approval mark issued by a nongovernmental certification body
- (B) manufacturer's self declaration of conformance
- (C) government certification signifying successful product testing
- (D) mark of origin indicating a product made in the European Community

108. The moment at support A is most nearly

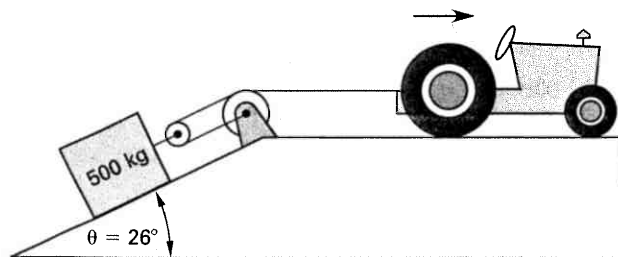


- (A) 1900 lbf
- (B) 2600 lbf
- (C) 3300 lbf
- (D) 3900 lbf

109. A 50 lbm mass is connected to the top of a vertical steel rod with a length of 36 in and a diameter of 2 in. The rod is clamped securely at its base. An integral damping system is modeled as a damping coefficient of 1.0 lbf-sec/in. Neglecting the rod's mass, the damping ratio is most nearly

- (A) 0.011
- (B) 0.036
- (C) 0.075
- (D) 0.098

110. A tractor pulls a 500 kg crate, initially at rest, up a 26° incline using the cable-pulley system shown. If the tractor moves with a constant velocity of 15 m/s after it is attached to the crate, and the cable remains taut throughout the hauling procedure, what is most nearly the tension in the cable? Neglect the mass of the cable-pulley system, and assume the coefficient of kinetic friction between the crate and ramp is 0.24.

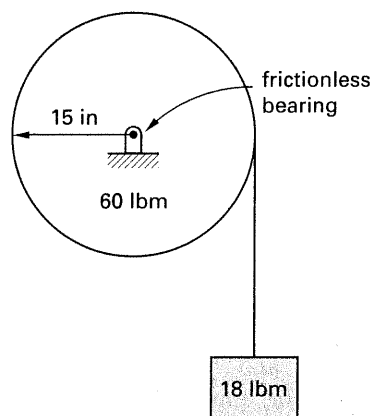


- (A) 530 N
- (B) 1100 N
- (C) 1600 N
- (D) 3200 N

111. Zinc blocks attached to the steel hull of a sea-going vessel at various locations below the waterline prevent corrosion. What is the name of this type of corrosion protection?

- (A) cathodic protection
- (B) anodic protection
- (C) passivation
- (D) galvanization

112. An 18 lbm mass hangs at the end of a wire wrapped around a solid cylinder that is rotating on a frictionless bearing as shown. The cylinder has a mass of 60 lbm and a radius of 15 in.



The tension in the string is most nearly

- (A) 11 lbf
- (B) 13 lbf
- (C) 15 lbf
- (D) 17 lbf

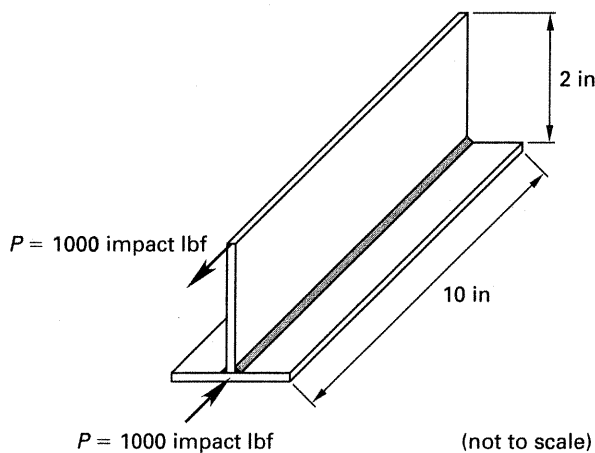
113. A machine exerts a force that varies cyclically. At the start of operation, the force increases linearly from zero to 32 lbf over 5 sec. It then decreases linearly from 30 lbf to 20 lbf over 4 sec, and then decreases linearly from 20 lbf to zero in 2 sec, at which time the cycle begins again. The average force during the first 20 sec of operation is most nearly

- (A) 13 lbf
- (B) 15 lbf
- (C) 17 lbf
- (D) 19 lbf

114. A solid 90 lbf cylindrical wheel with a radius of 5 ft is rotating at 54 rad/sec. The tangential force that must be applied to the wheel's contact surface in order to reduce the rotational speed by one-third in 30 sec is most nearly

- (A) 4 lbf
- (B) 10 lbf
- (C) 40 lbf
- (D) 100 lbf

115. Aluminum sheet is fillet welded to create the T-section shown. The weld leg size is $\frac{1}{8}$ in, sheet thickness is $\frac{1}{8}$ in, the weld length is 10 in, and both sides are welded. The allowable force per inch of weld leg is 5000 lbf/in. The joint is required to withstand an impact load of 1000 lbf suddenly applied parallel to the weld and 2 in from the fixed base as shown. What is most nearly the factor of safety?



- (A) 4.0
- (B) 6.0
- (C) 8.0
- (D) 16.0

116. A joint is made between two metal pieces by closely fitting their surfaces and distributing a molten nonferrous filler metal to the interface by capillary attraction. The pieces to be joined have a melting point of 1400°F, and the filler metal melts at 700°F. This process is most accurately termed

- (A) soldering
- (B) brazing
- (C) welding
- (D) forge welding

117. A 0.500 in nominal diameter hole and pin are to be combined during assembly. Drawings indicate tolerances as listed. The basic hole system is used.

parameter	high tolerance (in)	low tolerance (in)
hole diameter	$+1.6 \times 10^{-3}$ in	-0 in
pin diameter	-2.0×10^{-3} in	-3.0×10^{-3} in

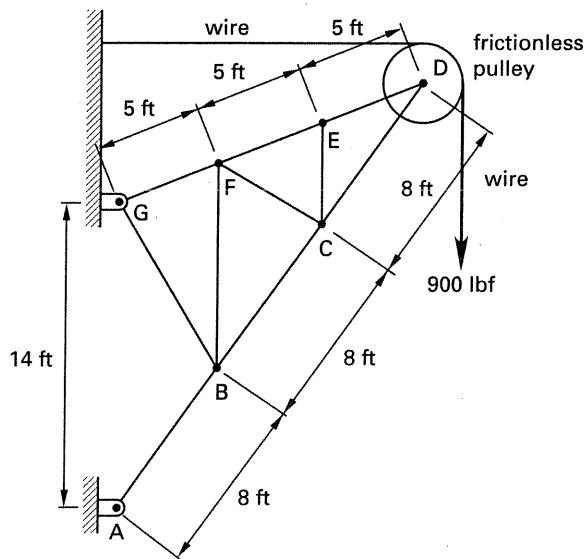
This fit is most properly designated as

- (A) RC7 free running fit
- (B) LC1 locational clearance fit
- (C) LT3 locational-transitional fit
- (D) FN2 medium drive fit

118. The motion of a lightly damped system is recorded. The amplitudes of two successive cycles of motion are recorded as 0.569 in and 0.462 in. The damping ratio is most nearly

- (A) 0.012
- (B) 0.033
- (C) 0.068
- (D) 0.095

119. A truss is constructed of pin-connected rigid members. The force in member BC is most nearly



- (A) 830 lbf
- (B) 880 lbf
- (C) 920 lbf
- (D) 970 lbf